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OFFER WITH CHOICES AND ACCEPT WITH DELAY: A WIN-WIN STRATEGY MODEL FOR AGENT-BASED AUTOMATED NEGOTIATION

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Abstract

This paper formalizes a model for strategic negotiation by an automated agent in bilateral agent-to-human multi-issue negotiations. Integrating insights from psychological and behavioral research, we hypothesize that compared to basic concession-based sequential-single offer and threshold-based immediate acceptance, a strategy based on simultaneous-equivalent offers and delayed acceptance makes a significant positive impact on both the economic and social-psychological outcomes of negotiations. We tested these hypotheses using a 2x2 experimental study conducted with 110 industrial subjects who negotiated with an automated agent on a 4-issue business purchase task. MANCOVA results suggested that compared to a baseline condition when the agent did not employ the proposed strategy, settlement efficiency and buyer's subjective responses were significantly higher when the seller agent provided simultaneous-equivalent offers, while the distance to Nash solution was significantly enhanced when the agent employed strategic acceptance delay. The findings confirmed the effectiveness of the proposed strategy and validated the efficacy of a novel implementation of an automated negotiation agent artifact.

Keywords: Automated negotiation, software agents, e-business & e-markets, negotiation strategy, multi-issue negotiation, Pareto efficiency, distance to Nash solution, satisfaction with negotiation outcome, perceived cooperativeness, win-win negotiation

Introduction

Contemporary negotiation research advocates the notion of “win-win”, in that it is always possible to “expand the pie” (Fisher and Ury 1981) to reach an “integrative” solution (Walton and McKersie 1965) or to arrive at a mutually beneficial agreement that maximizes settlement efficiency and fairness under appropriate conditions (Nash 1950; 1953; Raiffa 1982). Nevertheless, it is often difficult for human negotiators to identify and make tradeoffs necessary to reach optimum outcomes due to their limited information processing capacity and capability, cognitive biases, as well as socio-emotional obstacles (Foroughi 1995; Jelasi and Foroughi 1989; Neale and Bazerman 1991; Thompson and Hrebec 1996). The main purpose of designing Negotiation Support Systems (NSSs) is to facilitate human negotiators to reach better outcomes using decision and communication support tools (Bui 1994; Delaney et al. 1997; Kersten and Noronha 1999; Lim and Benbast 1993; Rangaswamy and Shell 1997; Shakun 1991).

Due to the rapid growth of global e-markets, there has been a significant interest in developing autonomous software agents that can serve as surrogates for human business decision-makers. In **automated negotiation**, software agents prepare and find contracts autonomously on behalf of the real-world parties they represent (Beam and Segev 1997; Lomuscio et al. 2003; Jennings et al. 2001). Agents offer a number of potential benefits to e-markets (Starke and Rangaswamy 2000). First of all, software agents decrease the transaction costs associated with human operation. Second, software agents can increase the efficiency of settlements even for semi-structured, multi-issue business bargaining problems (Oliver 1997). As compared to human agents who may deviate from their planned behavior, software agents stay aligned with the behavior patterns set by their human principals and are more rationally persistent with their aspirations. Third, agents can minimize some of the negative aspects of human negotiations, e.g., they can help individuals, who are uncomfortable with “haggling”, avoid face-to-face encounters. Altogether, software negotiation agents offer new commercial possibilities by turning conventional multi-issue online business transactions into negotiation-based transactions (Oliver 1997).

The negotiation strategy adopted by a negotiator is a key determinant to the outcome of negotiation. It is particularly important when one party is a software agent and the other party is assumed by a human (hereafter, we use the term “agent” to refer to a software agent in an agent-to-human multi-issue negotiation). A poorly designed agent will not be able to effectively deal with a skillful human counterpart adopting flexible strategies. Because external factors such as negotiation issues, rules, and environment are often predetermined (Neal and Bazerman 1992), in automated negotiation, a **negotiation strategy** corresponds to the private decision-making function set up for the agent to accomplish its goals. The primary challenge in formalizing a practical negotiation strategy is that an agent has only incomplete information about the counterpart, such as the counterpart’s utility function, resistance utility and deadlines. For example, in simple price bargaining, if the agent is overly tough, it may lose the chance to clinch a deal with its opponent; on the other hand, if it is too soft or accommodative, it would probably just earn marginal profits on the agreement. Another challenge arises from the potential tradeoffs in the presence of multiple issues (Fatima et al. 2004). If an agent does not recognize the preferences of the counterpart, the agent may fail to make tradeoffs for better outcomes even if they exist. Techniques such as rule-based concession (Matwin et al. 1991), case-based reasoning (Sycara 1990), machine learning with genetic algorithms (Oliver 1997) and Bayesian models (Zeng and Sycara 1998), and tradeoff mechanisms with estimation techniques (Coehoorn and Jennings 2004; Faratin et al. 2002; Jonker et al. 2007) partially address these challenges in developing agent-based negotiation strategies.

Despite such endeavors, the extant designs of software agents are still limited in the following ways. First, many negotiation strategies focus on the “distributive”, win-lose mode of negotiation (Walton and McKersie 1965), such as pushing the offers as near to the counterpart’s resistance price as possible (Zeng and Sycara 1998). Their effectiveness is only illustrated in single-issue negotiations (e.g., Faratin et al. 1998) and can be ineffective and inefficient in multi-issue negotiations (Lee and Chang 2008). Second, existing research tends to focus on a single dimension of a strategy in negotiations. That is, the issue of how to *make offers* (e.g., Faratin et al. 1998; 2002; Jonker et al. 2007; Zeng and Sycara 1998) and the issue of how to *respond to counteroffers* (e.g., Oliver 1997) are often studied separately. A well-designed strategy for an agent should be able to cover both. We are not aware of any previous design that integrates the two dimensions of strategy to form a comprehensive strategy. Third, empirical examinations on the effectiveness of existing agent strategies are mostly performed in agent-agent simulations, but not in agent-to-human negotiations. Therefore, a deeper understanding of the effect of agent negotiation strategies on a human counterpart’s perception is lacking.

In this paper, we propose a negotiation strategy model for a software agent in agent-to-human multi-issue negotiation. Our model strives to foster win-win negotiations and consists of two strategy dimensions: it makes simultaneous-equivalent offers rather than sequential-single offers and it employs delayed acceptance rather than immediate acceptance of a counteroffer that meets the agent's bottom-line. Two research questions are examined:

1) Will simultaneous-equivalent offers and delayed acceptance enhance the negotiation outcome?

2) How do the two strategy dimensions affect the human counterparts' subjective evaluations of the negotiation?

We implement the strategies as decision algorithms programmed in an agent. This allows us to empirically evaluate both the economic, utility-based outcomes of different negotiation strategies as well as their social-psychological effects. Furthermore, we test the agent in a B2B electronic marketplace scenario to demonstrate their potential applicability in online business.

The paper is organized as follows. The next section presents important concepts underlying the notion of win-win negotiation, and discusses related research in the automated negotiation literature. We then propose the design of our strategy based on insights from psychological and behavioral research on negotiation. We next describe a 2x2 experiment on multi-issue negotiations between a software agent (as seller) and a human subject (as buyer). Finally we report on the analysis of experimental data and implications.

Theoretical Development

The fundamental reason to negotiate is to arrive at a mutually acceptable agreement in the presence of different goals or expectations from negotiating parties. In negotiation literature, a negotiator's expectation is often known as the negotiator's **aspiration**. Aspiration is used either to refer to the best settlement point that one can achieve (Yukl 1974), the zero profit point (Chertkoff and Esser 1976), or a region between the best hoped-for outcome and a worst resistance point (Lewicki et al. 2006, p. 120; Oliver et al. 1994; Walton and McKersie 1965; White and Neale 1991). In this study, we adopt the region-based concept of aspiration, with the upper bound defined as a *target utility*, referring to the point where a negotiator feels satisfied to conclude the negotiation. The lower bound of the aspiration region is defined by a *reservation utility*, or resistance utility, a subjective threshold that can be matched with a negotiator's objective bottom-line situation. The objective bottom-line situation is also known as one's best alternative to a negotiated settlement (**BATNA**) (Fisher and Ury 1981; Raffia 1982). An *initial utility*, such as the asking price, is the utility point matching the very first offer (Lewicki et al. 2006, p. 120)

A negotiation can be associated with a single issue or with multiple issues (Raiffa 1982). A **single-issue** negotiation is often a zero-sum or distributive game with only one winner (Walton and McKersie 1965). Negotiators often employ distributive strategies such as pushing for a settlement close the counterpart's resistance point, thereby "claiming" the largest part of the settlement. In **multi-issue** negotiations (e.g., when negotiating purchase quantity, unit price, delivery time, warranty, and payment terms together), the negotiation situation is often non-zero-sum or integrative (Walton and McKersie 1965) in that there can be more than one way for negotiators to achieve their goals. As there are more dimensions in the solution, there are additional opportunities for parties to tradeoff their different interests over the issues, and hence achieve better outcomes (Fisher and Ury 1981; Raiffa 1982).

Economic View on Negotiation

Negotiation outcomes can be divided into two broad groupings: economic outcomes and social-psychological outcomes (Thompson 1990). The economic perspective primarily assesses negotiation outcome based on the efficiency and fairness of the allocation of resources in a negotiated settlement. *Settlement efficiency* reflects how "optimal" the settlement is for negotiation parties. **Individual efficiency** reflects the extent to which individual utility payoffs approach the maximum value. At the dyadic level, **joint efficiency** reflects the extent to which a dyad's joint payoffs approach a frontier. The basic theory underlying the optimization of negotiation outcomes is best known with the notion of *Pareto efficiency*. A Pareto-efficient agreement is one where no other agreement results in both parties being jointly better off. A Pareto-efficient frontier refers to the set of Pareto-optimal agreements, i.e., the locus of achievable joint evaluations beyond which no additional joint gains are possible (Raiffa 1982). In experimental negotiation literature, joint efficiency (often referred to as *joint utility*) can be measured by summing up individual utility scores or by calculating the distance from the settlement point to the Pareto-efficient frontier (i.e., *distance to Pareto-efficient frontier*) (Tripp and Sondak 1992).

Fairness or equality connotes the second aspect of settlement quality. *Settlement fairness* reflects how "fair" the settlement is with regard to principles such as equality, equity, justice and needs. Nash (1950, 1953) integrated the

Pareto standard with a set of fairness principles to define what came to be known as the Nash bargaining solution. The Nash bargaining theory strives to maximize the joint efficiency of two negotiation parties while maintaining fairness. Nash imposes three axioms: independence of irrelevant alternatives, efficiency, and symmetry. The *Nash solution* or *Nash equilibrium* is a single point that satisfies Pareto efficiency and fairness given the three axioms. Simply, this solution is a fair settlement that maximizes joint efficiency. Therefore, the fairness of a settlement can be measured by the distance between the settlement and the Nash solution (i.e., *distance to Nash solution*) (e.g., Lim and Benbasat 1993; Goh et al. 2000). The smaller the distance is, the better the settlement fairness is. Figure 1 illustrates these concepts.

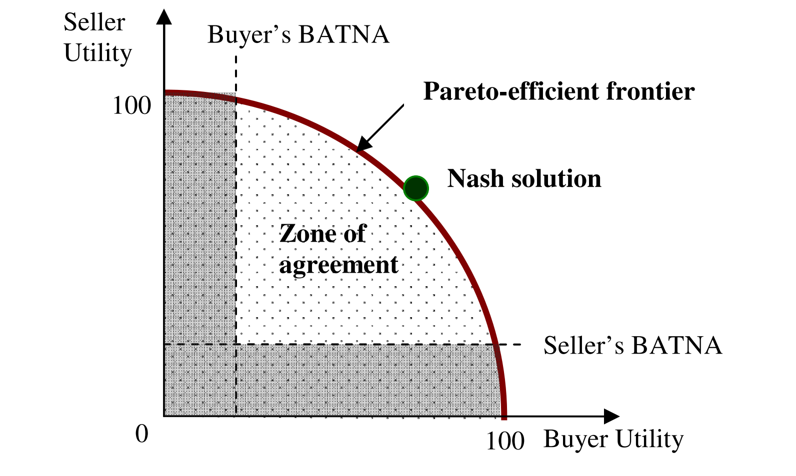

Figure 1. Buyer-Seller Utility Graph in Multi-Issue Negotiations

Because communication invokes a cost itself, the process efficiency is another realistic consideration in negotiations. As the complexity of a negotiation task increases, negotiation often becomes a prolonged process. Generally speaking, other outcomes being equal, it is more desirable to shorten the time to reach an agreement. The **time to settlement** can be measured by the time taken from the beginning of the negotiation to the point when an agreement is reached. The number of **rounds to settlement** is another measure of process efficiency.

Not all negotiations lead to mutual agreements. The quality of a negotiation can be indicated by whether an agreement is reached, assuming that a zone of agreement (see Figure 1) exists. It can be measured by an *impasse ratio* or inversely, a **settlement ratio**, the ratio of unsettled or settled cases over all negotiation cases (Tripp and Sondak 1992). The lower the impasse ratio is, or the higher the settlement ratio, the better the process efficiency is.

Social-psychological View on Negotiation

Satisfaction with the settlement is conceivably the most important subjective outcome used in empirical negotiation support systems research (e.g., Delaney et al. 1997; Eliashberg et al. 1992; Foroughi et al. 1995; Lim and Yang 2007; Oliver et al. 1994; Perkins et al. 1996; Rangaswamy and Shell 1997). *Satisfaction with the outcome* reflects the subjective belief that a negotiator has achieved efficient and fair solutions (Lim and Benbasat 1993). **Perception of the counterpart,** or perception of the other party (Thompson 1990), refers to a negotiator's judgment of his/her counterpart that is associated with a general social-psychological concept of person perception, such as *trait inference* (e.g., intelligence, sociability, expertise, cooperativeness, friendliness), or *attributions* that negotiators make to explain the behavior of the opponent (e.g., ethics, tactics, and strategies) (Morris et al. 1999; Tinsley et al. 2002). In this study, perception of the counterpart refers to the perceived cooperativeness of the counterpart.

Research has suggested that a negotiator's subjective evaluations of the negotiation outcome are predictive of his/her **desire for future relationships** (Oliver et al. 1994). This can be attributed to the fact that in most real-life negotiations, negotiators can not directly evaluate the objective utility achieved by their counterparts and the fairness of the settlement; therefore, they judge the negotiation outcome based on subjective evaluations of the opponent's behavior such as concession patterns and other social cues.

Summarizing the above, from an individual negotiator's perspective, the most desirable negotiation outcome is achieved when the settlement is economically efficient and fair, and at the same time the counterpart is happy about the settlement as well as the interaction with the negotiator. In order to achieve a desirable negotiation outcome, various negotiation strategies have been devised. The following section reviews the existing automated negotiation literature addressing the strategy issue and its impact on related aspects of negotiation outcome.

Related Work on Strategies for Agent-Based Negotiation

Research in designing practical agent-based negotiation strategies can be grouped into three *non-exclusive* approaches: heuristics, machine learning, and argumentation. Heuristic methods are proposed to overcome limitations of game-theoretic approaches (Nash 1950; 1953) which assume perfect information and rationality that are rarely applicable to real-life negotiations (Raiffa 1982). A **heuristics approach** acknowledges that an agent's utility function is usually private and there is a cost associated with computation and decision making. Therefore agents search the zone of agreement in a non-exhaustive fashion (Jennings et al. 2001). Earlier research (Faratin et al. 1998) categorizes an agent's decision functions in time-dependent, resource-dependent, and behavior-dependent manners. For each negotiation issue, the next offer is calculated as a simple function of time, resource, or counterpart behaviors. A multi-issue negotiation strategy (in deciding the next offer) is subsequently modeled as a "weighted combination" of these single-issue functions/tactics (Faratin et al. 1998, p. 166). Nevertheless, this method looks at issues separately, and ignores the opportunity for tradeoff among multiple issues to achieve more win-win solutions (Lee and Chang 2008). In order to address this limitation, an extended strategy applies fuzzy logic to allow a negotiation agent to approximate the opponent's preference structure, and thus make tradeoffs in its offers based on the similarity to the opponent's last offers (Faratin et al. 2002). Simulation results show that such tradeoffs can lead to higher joint gains for the agents. However, empirical studies confirming the efficacy of such agents in agent-to-human contexts are lacking. There is a need for more "extensive evaluation" (Jennings et al. 2001, p. 210).

The **machine learning approach** to automated negotiation focuses on the design of guessing heuristics, i.e., an agent's methods to learn about its counterpart (e.g., opponent's resistance point) and external world (e.g., interest rate) to adjust its negotiation strategy. For example, earlier research has studied the use of genetic algorithms to find the best offer strategy (Oliver 1997). Another study presents a modeling framework pertaining to an agent's belief about the environment and information about the opponent(s) (Zeng and Sycara 1998). This information is updated using Bayesian rules. The agent "always chooses the action that maximizes the expected payoff given the information available at this stage" (Zeng and Sycara 1998, p. 131). The essence of such approach is to guess the counterpart's resistance point and push the agent's next offer closer to it, underlining the "distributive" mode of negotiation (Walton and McKersie 1965). Later studies examine more sophisticated learning mechanisms for multi-issue negotiations. For example, research indicates that "kernel density estimation" (Coehoorn and Jennings 2004) or partial ordering of attribute weights (Jonker et al. 2007), as an alternative to fuzzy logic (Faratin et al. 2002), can also be used to learn about opponent's preferences, such that the next "tradeoff" offer can be composed based on the estimated opponent's utility function and one's own utility function. However, the estimation of opponent's preference structure generally requires a large number of prior negotiation trials or an initially-default-later-update process, before an agent can learn a good negotiation strategy. Such conditions are not easily met in the real-world. It is also observed that existing approaches extensively focus on examining the strategy dimension of offer-making.

The third category of agent-based automated negotiation research, the **argumentation approach**, focuses on how to make offers more attractive by allowing additional information to be exchanged (Huang et al. 2006; Kraus et al. 1998; Parsons et al. 1998). The additional information can be in the form of a message that accompanies an offer to justify why the offer is composed in that particular way; or to give criticism of a counteroffer. In this paper, we do not manipulate the argumentation aspect, and adopt a negotiation protocol of pure offer and counteroffer exchanges.

A Strategy Model for Win-Win Negotiation

Our proposed negotiation strategy focuses on the fundamental aspects/dimensions of communication in negotiation (Tutzauer 1992), i.e., making offers and reacting to counteroffers. Specifically, an **offer strategy** is a plan associated with a negotiator's decisions in making offers, and an **acceptance strategy** is a plan associated with reactions to a counteroffer. The two strategy dimensions coordinate with each other and form a comprehensive strategy model.

This model has the following assumptions and boundaries. First, it assumes that the negotiation agent has full knowledge about *itself*. That is, the agent is preloaded with the private task information including the utility function, aspiration levels, and deadline, as well as the public task information of the issues to be negotiated. This model does not consider the situation where issues can be restructured or manipulated (Kersten et al. 1991; Sycara 1991) for strategic advantage during the actual negotiation process. Second, the model assumes that the agent has limited knowledge about its *counterpart*. It does not presuppose the agent has knowledge of its counterpart's preference structure, aspiration levels, or deadlines a priori. Third, the model assumes that all parties comply with a simple set of ***negotiation rules***, based on the bilateral alternate offer protocol *(*Rubinstein 1982). Parties take alternate turns to make offers and counteroffers without argumentation. Negotiation terminates if one party accepts the other's offer at a certain round, or rejects an offer labeled as "final" by the proposing party. The negotiation rules are public information.

Our strategy strives to accomplish a win-win outcome defined by both economic and social-psychological outcomes (Fisher and Ury 1981; Raiffa 1982; Thompson 1990; 2009). The success of an agent's strategy is explicitly assessed by the utility payoffs as well as the counterpart's subjective reactions. Figure 2 presents the research model.

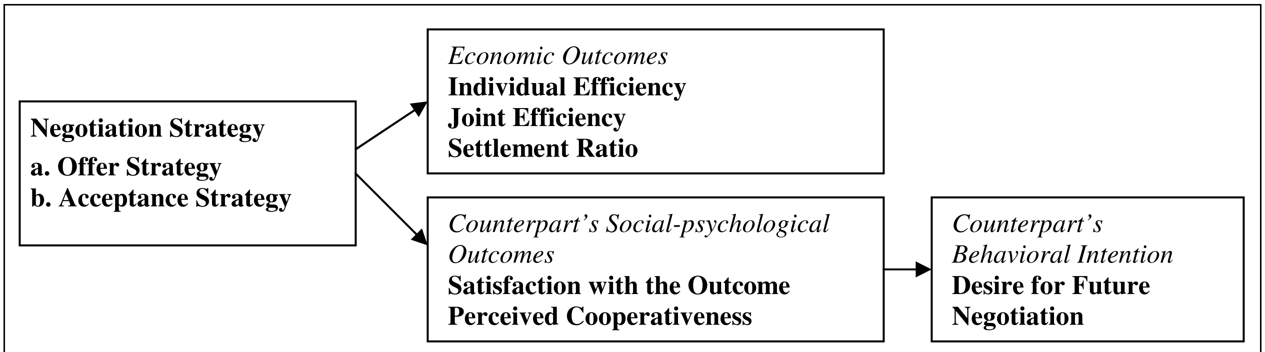

Figure 2. The Research Model

Offer Strategy

Regarding making offers, an intuitive strategy is to start with a tough offer and to make monotone concessions from it (Raiffa 1982, p. 128). In experimental psychology, it is well indicated that negotiators who make tough opening offers get higher settlements than do those who make low or modest opening offers (Chertkoff and Conley 1967; Cohen 2003; Pruitt and Syna 1985; Weingart et al. 1990). However, a tough opening offer may be harmful to long-term relationships as it communicates high self-concern and an attitude of hardiness; conversely, however, if an offer is too soft and accommodative, the negotiator sacrifices his/her own substantive payoffs (Pruitt and Rubin 1986). A **sequential-single offer** strategy is an offer strategy when a negotiator adopts a concession-based approach by starting with a tough offer, and concedes by making offers of a lower self-utility sequentially in subsequent rounds. An alternative to this basic offer strategy is the use of **simultaneous-equivalent offers** recently proposed in social psychology (Leonardelli et al. 2008; Medvec et al. 2005a; 2005b; Thompson 2009, p. 86). This method involves presenting the other party with at least two offers of equal value to oneself at each round.

From an economic perspective, the merits associated with simultaneous-equivalent offer strategy are twofold. First, in a multi-issue negotiation, the possibility to make tradeoffs among issues allows the construction of alternatives that are of *equivalent* (or at least comparable) utility to the offering party. This mechanism does not harm the negotiator's own substantive payoffs. Second, when the alternatives are offered *simultaneously*, the counterpart can evaluate them based on his/her private utility function/preference structure, although unknown to the proposing party. Therefore, the counterpart's utility corresponding to a negotiation settlement can be potentially improved, and consequently, the overall settlement efficiency is increased.

By making simultaneous-equivalent offers, the agent also increases the chances that one of the offers will appeal to the counterpart by matching his/her target point. In an open, e-market environment where an agent can encounter a diversity of potential buyers, simultaneous offers can increase the likelihood of acceptance. In human-to-human negotiation experiments, this method has been shown to lead to better acceptance rate as well as the opponent's satisfaction towards the offers (Leonardelli et al. 2008; Medvec et al. 2005a).

H1. *Compared to the sequential-single offer strategy, the* ***individual efficiency*** *of the counterpart will be improved (e.g., buyer utility is higher) when the agent makes simultaneous-equivalent offers.*

H2. *Compared to the sequential-single offer strategy, the* ***joint efficiency*** *will be improved (e.g., joint utility is higher, or distance to Pareto-efficient frontier is smaller) when the agent makes simultaneous-equivalent offers.*

H3. *Compared to the sequential-single offer strategy, the* ***settlement ratio*** *will be higher when the agent makes simultaneous-equivalent offers.*

Satisfaction with negotiation outcome is conceptualized as a two-dimensional construct (Lim and Benbasat 1993): perceived settlement efficiency that corresponds to a negotiator's confidence with solution, and perceived settlement fairness corresponding to a negotiator's evaluation of his/her outcome in comparison with the opponent. Because simultaneous-equivalent offers are expected to lead to a higher utility to the other party, the other party will feel better about the outcome. Furthermore, simultaneous offers can create a contrast effect (Simonson and Tversky 1992) in that an offer is viewed more favorably in the presence of other (poorer) choices than when it is presented by itself. Therefore, if the counterpart accepts an offer among simultaneous offers, s/he is likely to feel more satisfied.

H4. *Compared to the sequential-single offer strategy, counterparts will have a greater* ***satisfaction with the outcome*** *when the agent makes simultaneous-equivalent offers.*

An important psychological outcome in negotiation is a negotiator's judgment on the faithfulness, friendliness, and flexibility of the counterpart (Curhan et al. 1996; Thompson 1990). This is defined as the *perceived cooperativeness* in our model. Past research uses similar notions such as perceived collaborative/negative climate (Foroughi et al. 1995), satisfaction with the general atmosphere (Eliashberg et al. 1992), or satisfaction with the partner (Kwon and Wingart 2004) to describe the subjective feelings related to the negotiation partner. One of the basic signs of cooperativeness is to give choices, rather than demanding an unfriendly yes-or-no answer to a single choice. The presentation of multiple choices in a simultaneous-equivalent strategy serves as a social cue (Fiske and Taylor 1991) to communicate an apparent signal of flexibility and commitment in reaching agreement. Therefore, the counterpart is likely to perceive a higher degree of cooperativeness on part of the agent.

H5. *Compared to the sequential-single offer strategy, counterparts have a higher* ***perceived cooperativeness*** *towards the agent when the agent makes simultaneous-equivalent offers.*

Acceptance Strategy

The acceptance strategy deals with how to react to an offer from the counterpart. A straightforward acceptance strategy is the "threshold decision rule" (Oliver 1997) by making an **immediate acceptance** of an offer that exceeds the bottom-line utility. In a multi-issue negotiation, however, the negotiating parties' preferences may not all be in conflict with each another. Thus, even when an offer meets an agent's reservation point, there could still be solutions that are better for both parties. An agent could explore better offers without sacrificing the counterpart's utility.

In contrast to the immediate acceptance strategy, the **delayed acceptance** strategy is a method to further explore offers although the counterpart's offer has met the agent's reservation utility. As a quick recap, we have defined two aspiration levels for strategic decision making. First, the method specifies a *reservation utility* of the agent, which refers to the subjective resistance point matching an objective bottom-line based on its BATNA (Fisher and Ury 1981; Raffia 1982). Second, the agent maintains a *target utility* where the negotiator is satisfied to conclude a negotiation, which usually has "a reasonable distance from the bottom-line" (Raffia 1982, p. 127). The region set by the reservation utility and the target utility determines the region in which a negotiator is willing to explore offers. With this strategy, an agent first initializes the reservation utility to be equal to its BATNA utility. As negotiation proceeds, in case the agent receives an offer which exceeds its reservation utility (but not the target utility), the agent dynamically adjusts its reservation utility to match the utility to the offer, and continues negotiating for better agreements. This allows the agent to avoid a "premature closure" (Kelly 1966) by increasing its chances of getting a better deal. Consequently, the joint efficiency will also be increased.

Undoubtedly, delaying in accepting an offer still involves a risk of not being able to get better offers in later rounds. To minimize this risk, besides dynamically updating the agent's reservation utility to match the best offer from its counterpart, the method allows the agent to re-calculate/shorten the remaining negotiation rounds depending on the relative attractiveness of the counterpart's offer. This allows the agent to avoid being overly "greedy" in exploring better offers. Thus,

***H6**. Compared to the immediate acceptance strategy, the **individual efficiency** of the agent is higher when the agent adopts a delayed acceptance strategy.*

***H7**. Compared to the immediate acceptance strategy, the **joint efficiency** is higher when the agent adopts a delayed acceptance strategy.*

A negotiator often experiences a counterfactual thinking when his/her proposal is accepted by the counterpart quickly: "I must have asked for too little. The counterpart is taking advantage from me" (Bazerman 1983). The negotiator may suspect that the other party knows too much or has insight into an unseen advantage. In cognitive negotiation theories, such a regrettable state of affairs is often described as the *winner's curse*, which refers to the tendency of negotiators, particularly in an auction setting, to settle too quickly on an item and then subsequently feel a discomfort about an agreement that comes too easily (Ball et al. 1991; Bazerman and Samuelson 1983; Neale and Bazerman 1991). Recent research suggests that the counterfactual thinking makes a negotiator feels less satisfied when having one's first offer accepted (Galinsky et al. 2002). By delaying an acceptance decision, the agent can continue negotiating by invoking its offer strategy, making chances for the settlement to be reached through progressive concession. Past studies indicate that parties feel better about a settlement when the negotiation involves a progression of concessions than when it didn't (Baranowski and Summers 1972; Deutsch 1958). Therefore,

***H8**. Compared to the immediately acceptance strategy, the counterpart's **satisfaction with the outcome** will be higher when the agent adopts a delayed acceptance strategy.*

Desire for Future Negotiation

The willingness to negotiate in the future is a critical factor in dyadic contexts such as buyer-supplier relationships. In an earlier experimental study (Oliver et al. 1994), negotiators' desire for future interaction with their partners is shown to be significantly correlated with satisfaction with the current negotiation outcome. The relationship works from two possible routes (Oliver et al. 1994). Satisfaction may influence future negotiation behavior through the cognitive mediator of interpersonal trust (Kumar 1989). Alternatively, as satisfaction is raised from favorable outcomes, it engenders confidence in this particular counterpart and hence instrumental motivation (Vroom 1964). We therefore predict that a positive evaluation of the negotiation outcome and the counterpart will lead to one's desire to continue with future relationships.

***H9.** The counterpart's satisfaction with the outcome and perceived cooperativeness of the agent is positively associated with a **desire for future negotiation**.*

Experiment Design

A 2x2 experimental study was designed to test the hypotheses. The subjects were tasked to play the role of a buyer negotiating a purchase with a supplier over the supplier's portal website. The supplier (seller) was assumed by an automated software agent, but subjects were not told that the seller was played by a software agent. Figure 3 shows the screen used in the experiment.

Before the main experiment, we conducted a pilot study involving 20 participants who were business executives and researchers. The participants were invited to go through the experiment as subjects and to criticize the experiment instrument and procedure. Experimental procedure was smoothened, and questionnaire items were polished based on their feedback. Subjects for the main experiment were working professionals with experience in organizations and decision making. In total, 110 subjects were recruited from an international business park with diverse backgrounds including retailing, manufacturing, media and services, IT, and R&D. Their average age was 30.5 with 55.5% males. All subjects had at least one year of working experience, and the majority (61.5%) had worked for 2-10 years. All subjects had experience with group work. On average, the subjects had high computer efficacy (4.35 out of 5-point Likert scale); and had been moderately exposed to online shopping (3.25 out of 5), business decisions (2.80 out of 5) and business negotiation activities (2.42 out of 5).

As an incentive for active participation in the experiment, subjects received tiered cash rewards based on their negotiation performance. The performance was measured by the individual utility earned by the subject on the negotiated agreement, with higher cash rewards given to subjects achieving higher individual utility scores. Each subject received $20 for their participation. Additionally, the top 10%, the second 10%, and the third 10% out of all subjects received $50, $30, and $20 cash respectively. The top winner also received a PDA phone worth $750.

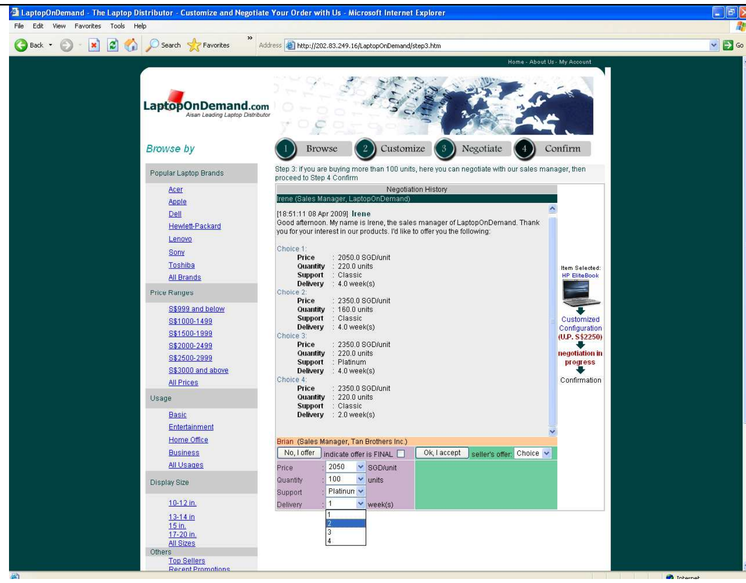

Figure 3. Sample Interface for the Agent-to-human Negotiation

Experiment Task

This experiment involved a negotiation task about online purchase of laptop computers with four issues comprising unit price, quantity, service level, and delivery terms. The task was adapted from a validated negotiation scenario based on real-world manufacturing contract negotiations (originally developed by Jones 1988; and used in experimental negotiation studies including Delaney et al. 1997; Foroughi et al. 1995; Goh et al. 2000). In the task, subjects (buyers) and agents (sellers) both used private utility functions which were a weighted sum of the utilities assigned to the four issues. However, buyers and sellers had different weightings such that their interests were not in direct conflict with each other. In game-theoretic terms, the structure of the task created a *non-zero-sum* game with 728 discrete alternatives, where integrative, win-win solutions were possible. Both the buyer and the seller were given the same bargaining power, i.e., BATNA values that represented 44 utility points.

Independent Variables and Control Variables

A 2x2 between-subject factorial experiment design was employed to test our hypotheses. Two independent variables, the offer strategy and the acceptance strategy of the seller, were manipulated using a decision algorithm coded into a web-based negotiation agent system (refer to Yang and Singhal 2009 for a more detailed discussion of the system design framework). The subjects were randomly assigned to negotiate with an agent configured under the four treatment conditions. Figure 4 depicts the design. In each cell, the first number indicates negotiation cases and the number in bracket refers to the number of cases where agreements were reached.

		Offer Strategy	
		SEQ *(sequential-single offer)*	**SIM** *(simultaneous-equivalent offer)*
Acceptance Strategy	**IMM** *(immediate acceptance)*	28 (21) subjects	26 (21) subjects
	DLY *(delayed acceptance)*	27 (20) subjects	29 (22) subjects

Figure 4. Experimental Design

We formalized the ***simultaneous-equivalent offer strategy*** (SIM condition) with the following decision algorithm. To start off, the agent's initial offer utility (U_{offer}) is set at 80 ($U_{initial}$). **a)** To generate the four offers with U_{offer}, the agent searches the zone of agreement for offer alternatives and selects a subset of the alternatives with their corresponding utility values equal to or greater than U_{offer}, then further selects four of them as offers with *each offer optimizing one of the four negotiation issues to the buyer*. The agent then presents these four simultaneous-equivalent offers (Figure 5) to the buyer and invites a response (accept, or reject with counteroffer). **b-1)** If the buyer accepts any of the offers, the negotiation episode is concluded; **b-2**) Else if the buyer proposes a counteroffer, the agent invokes the *acceptance strategy*. **c-1)** If the *acceptance strategy* returns "accept", the agent accepts the counteroffer and the negotiation episode is concluded; **c-2)** Else if the *acceptance strategy* returns "offer", the agent makes a monotone decreasing concession (i.e., update U_{offer} by reducing U_{offer} monotonically; Yang and Singhal 2009) and returns to step **a**. **d)** If the planned number of rounds (R is initialized as 9) has been reached, and the agent makes a final set of offers matching $U_{reservation}$ for the buyer to decide (accept, or reject with final counteroffer). As a comparison, ***sequential-single offer strategy*** (SEQ condition), used as the baseline offer strategy, differs from SIM only in that the agent randomly picks one of the offers generated in step **a** for presentation to the buyer.

The ***delayed acceptance strategy*** (DLY condition) applies the following decision algorithm. Upon receiving a counteroffer at round *i*, the agent evaluates it using its own utility function and adjusts its private decision parameters using the following rules. **1)** If the counteroffer is marked "final" and the counteroffer utility (U_i) is above the BATNA utility (U_{BATNA}), return "accept"; **2)** Else if U_i is above the target utility (U_{target} is set at 60) (i.e., the counteroffer falls in the Acceptance Region in Figure 5), return "accept"; **3)** Else if U_i is less than U_{target} but above the current reservation utility ($U_{reservation}$ is initialized as U_{BATNA} ; where U_{BATNA} is set at 44) (i.e., the counteroffer falls in the Aspiration Region in Figure 5), set $U_{reservation} = U_i$, and re-adjust the total planned concession rounds to be $R*(U_i - U_{reservation})/(U_{initial} - U_{BATNA})$ and returns "offer"; **4)** Else if U_i is less than $U_{reservation}$ (i.e., the counteroffer falls in the Rejection Region in Figure 5), returns "offer". As a comparison, in the baseline acceptance strategy ***immediate acceptance*** situation (IMM condition), the agent simply returns "accept" if the utility computed from the counteroffer is greater than U_{BATNA}, else it returns "offer".

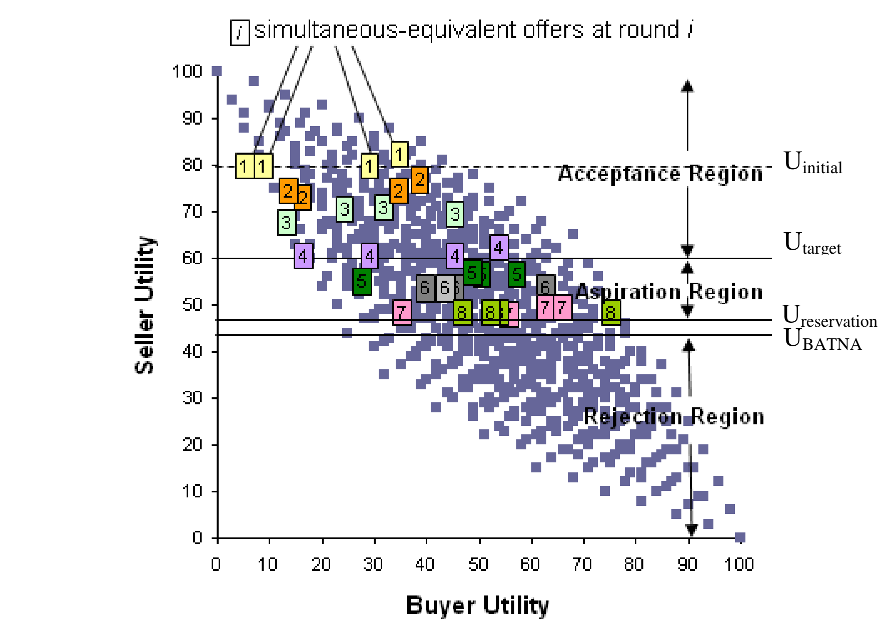

Figure 5. An Illustration of the Agent's Strategy in the Experiment Task

Other pertinent factors were controlled in the experiment. The negotiation rules were controlled by using the same alternate offer protocol for all conditions and allowing both parties to indicate a final offer at any time. The same negotiation task was used in all conditions. The effects of *individual differences* (e.g., age, gender, past experience, personality) of buyers and their *target utility* values were randomized as a result of random assignment of subjects to the different treatment conditions. The *target utility* of sellers was kept constant as specified in the agents' decision algorithm across all treatments. The negotiation website interface was controlled. The effect of *physical environment* was controlled by using the same training room throughout all sessions. The *experimenter effects* were controlled by using the same facilitator with a standardized instruction script across all sessions.

Dependent Variables

Individual utility was calculated as the weighted sum of utility scores from the issues based on the multi-attribute utility model (Keeney and Raiffa 1991; Raiffa et al. 2002). Suppose the negotiating parties, A and B, have reached an agreement on three issues, X, Y and Z. Based on the agreement and A's private utility function, A derives the following utilities, or weightage points: U_{xa} for X, U_{ya} for Y, and U_{za} for Z. Similarly, B derives U_{xb} for X, U_{yb} for Y, and U_{zb} for Z. The individual efficiency of A (U_a) and B (U_b) were calculated as ($U_{xa} + U_{ya} + U_{za}$) and ($U_{xb} + U_{yb} + U_{zb}$) respectively.

The joint efficiency was measured in two ways: the distance to Pareto-efficient frontier as well as the distance to Nash solution. The smaller the distances are, the better the settlement efficiency is. Mathematically, *distance to Pareto-efficient frontier* is calculated as $\min_{i=1}^{n} \left(\sqrt{(U_a - U_{ai})^2 + (U_b - U_{bi})^2}\right)$, where U_{ai}, U_{bi} denote A's and B's utilities corresponding to an efficient solution *i*. Here *i* is a sequential index of efficient solutions, and *n* is the total number of efficient solutions.

Distance to Nash solution was calculated as $\sqrt{\left(U_a - U_{a\_nash}\right)^2 + \left(U_b - U_{b\_nash}\right)^2}$, where U_{a_nash}, U_{b_nash} denote A's and B's utilities corresponding to the Nash solution.

Settlement ratio was calculated as the ratio of the number of settlements over the total number of negotiation cases (i.e., sample size in each condition). Process efficiency was measured in both the *settlement time* (in minutes) and *settlement rounds* from the beginning of the negotiation to the point when an agreement was made.

The social-psychological perspective of negotiation outcomes were evaluated using a post-negotiation questionnaire (Table 1). Items were adapted from previous studies whenever possible (Curhan et al. 2006; Eliashberg et al. 1992; Foroughi et al. 1995; Rangaswamy and Shell 1997; Oliver et al. 1994). Otherwise, new instruments were developed.

Table 1. Measurement of Subjective Negotiation Outcome

Dependent Variables		**Items**	**Scale**
Satisfaction with the Outcome	Perceived Settlement Efficiency	How satisfied are you with the utility score you earned?	1-Extremely dissatisfied; 4-Indifferent; 7-Extremely satisfied
		How satisfied are you with the values of the agreement?	1-Extremely dissatisfied; 4-Indifferent; 7-Extremely satisfied
		What do you think of the agreement?	1-Much worse than expected; 4-As expected; 7-Much better than expected
		What do you think of the relative ranking of your utility score among all buyers?	1-I'm much lower than average; 4-I'm average; 7-I'm much higher than average
	Perceived Settlement Fairness	To what extent do you think the agreement was of equal utility value to you and the seller?	-5-The seller earns much higher utility score than me; 0-We obtained same utility scores; 5-I earn much higher utility score than the seller
		Do you think the final agreement is fair?	-5-The agreement is extremely biased towards the seller; 0-The agreement is fair; 5- The agreement is extremely biased towards me
Perceived Cooperativeness		Do you think the seller was considerate about your interests and concerns?	1-Extremely inconsiderate; 4-Moderately; 7- Extremely considerate
		Do you think the seller was rigid in making offers to you? (R)	1-Extremely flexible; 4-Moderately; 7-Extremely rigid
		Do you think the seller was friendly?	1-Extremely unfriendly; 4-Moderately; 7-Extremely friendly
		Do you think the seller was flexible in making offers to you?	1-Extremely rigid; 4-Moderately; 7-Extremely flexible
		What kind of "overall" impression did the seller make on you?	1-Extremely negative; 4-Neither negative nor positive; 7- Extremely positive

Desire for Future Negotiation	If there are needs in future, are you willing to interact with this seller again?	1-Not at all; 4-Moderately; 7- Perfectly
	If there are needs in future, are you willing to continue a business relationship with this seller?	1-Not at all; 4-Moderately; 7- Perfectly
	If another seller is available, would you be willing to negotiate with this seller in future?	1-No, prefer another; 4-Indifferent; 7-Yes, prefer this seller

Experimental Procedure

The experiment followed a three-stage procedure. In the pre-negotiation stage, subjects first read general instructions and were briefed about the procedure. Subjects were then given a task information sheet which described their role as the buyer. Their goal was to maximize their own utility scores over four negotiable issues for purchasing an IT product. To achieve the goal, they attempted to reach an agreement with their counterpart. It was emphasized that the higher the utility score the subjects achieved, the higher the cash awards they would be able to receive. Subjects were asked to take a quiz to make sure that they understood the task. They were also asked to record their target utility as the minimum point above which they would be satisfied. After this, the website and the negotiation rules (based on bilateral alternate offer protocol and the equal rights for both parties to make a "final" offer) were introduced. It was also clarified that an offer expires if it was not accepted at its present round, but the rule did not prevent a party from making an offer which was of equivalent value to one made in previous rounds. Finally, a pre-negotiation questionnaire was administered to record their past experience.

The second stage was the actual negotiation stage. Subjects negotiated with the agent until they reached an agreement, or until negotiation is terminated with no agreement when one party rejected the other party's final offer. No time limit from the experimenter was imposed for this stage.

The third stage was the post-negotiation stage. Upon completing the negotiation task, subjects were asked to record their agreement. They were then asked to complete a post-negotiation questionnaire whereby their perceptions towards the negotiation process and outcome were measured. Demographic information was also collected. The subjects were debriefed to keep their experience in this study confidential, and received their basic participation rewards. Performance rewards were announced three weeks after the commencement of the study.

Data Analysis and Discussion of Results

Construct Validity, Reliability and Control Check

Before hypothesis testing, we first checked the construct validity of dependent variables (outcome satisfaction, perceived cooperativeness, desire for future negotiation). Exploratory factor analysis with VARIMAX rotation showed that the (only) reversed item for perceived cooperativeness did not satisfy the convergent criteria; it was dropped from subsequent analysis. The remaining items showed satisfactory convergent and discriminant validity where the factor loadings for the intended constructs were greater than the desired threshold of 0.5 (Hair et al. 1995). Finally, reliability analysis was conducted and the results showed acceptable values on all constructs with a Cronbach's alpha greater than 0.7.

To examine internal validity, validation tests for controlled variables were performed to examine the effectiveness of the random assignment of the 110 subjects to the treatment conditions. Two-way MANOVA tests on subjects' individual differences (i.e., age; gender; year of working experience; past experiences of group work, computer usage, online shopping, business decisions and negotiations; personality traits; target utility), and the subjects' perception of the negotiation rules showed no significant differences across treatment conditions. Of the 110 subjects, 84 subjects reached an agreement with the seller agents as reported in Figure 4. We performed additional control checks on this subgroup. The results showed that the online shopping experience, target utility, and gender differed across different treatment conditions; hence, subsequent analyses used the three variables as covariates to rule out their effects on the dependent variables (Neter et al. 1990).

Analysis of Variance Tests and Hypotheses Testing

The two-way multivariate ANOVA with covariates test (MANCOVA) was used to investigate the effects of the two strategy variables. Multivariate ANOVA was used because it can test multiple dependent variables simultaneously and protect against the inflation of type I error if the dependent variables are correlated. The Appendix shows the descriptive statistics and profile plots of dependent variables across treatment conditions.

Table 2 summarizes the results of the two-way MANCOVA tests. The results show significant **main effects** of the offer strategy on buyer utility, distance to Pareto-efficient frontier (because using joint utility measure led to the same conclusions, we report only the distance to Pareto-efficient frontier for simplicity), satisfaction with the outcome, and perceived cooperativeness, as well as the **main effects** of the acceptance strategy on seller utility and distance to Nash solution. Interaction effects of the two variables were all insignificant. The effect of the strategy variables on settlement ratio was performed using logistic regression. The results indicated that the settlement ratio did not differ significantly. Post-hoc analysis to investigate this result is presented later.

Table 2. Summary of Two-Way MANCOVA Results (* p<.05, ** p<.01)

Independent Variables	Dependent Variables	η_p^2	Observed Power	F	Main Effects Significant? (p)
Offer Strategy	Buyer Utility	.176	.978	16.238	YES (.000**)
	Seller Utility	.006	.098	0.422	NO (.518)
	Distance to Pareto-Efficient Frontier	.179	.980	16.584	YES (.000**)
	Distance to Nash Solution	.024	.274	1.890	NO (.173)
	Satisfaction with Outcome				
	- Perceived Settlement Efficiency	.132	.918	11.530	YES (.001**)
	- Perceived Settlement Fairness	.101	.821	8.496	YES (.005**)
	Perceived Cooperativeness	.084	.739	6.936	YES (.010*)
Acceptance Strategy	Buyer Utility	.004	.086	0.318	NO (.575)
	Seller Utility	.070	.655	5.704	YES (.019*)
	Distance to Pareto-Efficient Frontier	.031	.333	2.396	NO (.126)
	Distance to Nash Solution	.063	.608	5.119	YES (.027*)
	Satisfaction with Outcome				
	- Perceived Settlement Efficiency	.004	.085	0.307	NO (.581)
	- Perceived Settlement Fairness	.001	.054	0.038	NO (.846)

A linear regression was conducted to test the effects of negotiation process and outcome variables on the desire for future negotiation. The regression model includes the strategy variables, their interactions, economic and subjective measures of negotiation outcome, as well as the control variables. Results indicate that perceived cooperativeness was significantly associated with buyers' intention for future engagement with the agent (β=0.457; p=0.000**).

Results and Discussions

MANCOVA results confirmed the effectiveness of **simultaneous-equivalent offer strategy** on the individual and joint efficiency of negotiated agreement (**H1** and **H2**). The buyer utility in the SIM condition (mean=72.3; s.d.=7.4) was significantly higher than that in the SEQ condition (mean=65.4; s.d.=7.7). The distance to Pareto-efficient frontier in the SIM condition (mean=4.9; s.d.=3.1) was significantly smaller than that in the SEQ condition (mean=9.4; s.d.=5.7). The agreements were reached in an average of 6.9 rounds under all conditions and there was no significant difference between SIM and SEQ conditions. This indicates that even though the total time to the settlement was longer in the SIM condition (mean=18.7 minutes; s.d.=9.4) than in the SEQ condition (mean=13.8 minutes; s.d.=6.2), it could be attributed to the time subjects spent on evaluating the multiple choices at each round. The process in SIM condition was considered efficient from the perspective of the number of rounds to settlement.

Other than positively enhancing the economic aspects of negotiation outcome, the simultaneous-equivalent offer strategy was shown to significantly enhance the subjective outcomes of negotiation. Subjects were more satisfied with the settlement efficiency when the agent adopted a SIM strategy (mean=4.8; s.d.=0.9) than those when agent adopted a SEQ strategy (mean=4.2; s.d.=1.1); they felt that the agreement was more favorable towards themselves (compared to towards the seller) in the SIM condition (mean=0.7;s.d.=1.5) than in the SEQ condition (mean=-0.4;s.d.=1.8) (**H4**). The results also suggest that when the agents made simultaneous-equivalent offers, they were perceived more cooperative (mean=4.2; s.d.=1.1) than otherwise (mean=3.7; s.d.=0.9) **(H5)**. Similar effects were observed in previous human-to-human negotiation experiments (Medvec et al. 2005a). Our results confirm the applicability of this strategy in building computational automated agents.

Interestingly, contrary to our hypothesis that the simultaneous-equivalent strategy should lead to a higher settlement ratio **(H3)**, the data showed no significant difference between SEQ (31 out of 55 cases) and SIM (33 out of 55 cases) conditions. Several explanations are plausible. We first ruled out the reason that the agent failed to accept a reasonable offer. This is supported by server logs that verified that the agent behaved according to the acceptance algorithm. Second, there can be a chance that buyers in the unsettled cases in the SIM condition overlooked the implication of rejecting a final offer. However, this possibility could be ruled out because of the random assignment procedure. Third, it was possible that buyers in the SIM condition who were aware of the "final" offer rule yet still tried their luck by counter-proposing a very tough (high self-utility) final counteroffer to the seller. According to the negotiation rule, the agent would respond with a summary rejection if such a counteroffer was below its BATNA. Post-hoc analysis on the buyer's final-offer utility showed some evidence for this postulation. In face of the last chance ("final" offer round), buyers in the SIM condition made much "tougher" offers (mean of the self-utility=74.6; s.d.=9.6) than buyers in the SEQ condition (mean of self-utility=68.8; s.d.=8.3) at the p=0.002 significance level. Therefore, it is possible that when agents gave simultaneous offers (that communicated flexibility and cooperativeness), it triggered the buyers to aspire for better outcomes by making tougher final counteroffers that fell into the agent's rejection region. That is, the in situ "escalation" of buyers' target utility might have neutralized the effect of the simultaneous-equivalent offer strategy to increase settlement ratio. Future study is needed to investigate these two competing effects.

The post-hoc analysis is in line with some earlier aspiration research in social psychology: if a negotiator communicates a tough attitude (giving a tough initial offer and small concessions), the opponent tends to lower his/her aspiration level and make a more favorable final offer, albeit with a tough/negative person perception of the negotiator (Siegel and Fouraker 1970; Yukl 1974). Conversely, what our findings suggest is that if a negotiator (the software agent in our context) communicates a soft and flexible attitude by giving simultaneous offers, the counterparts may increase or escalate their aspirations. If this assertion is true, further exploration of the theoretical underpinnings of simultaneous-equivalent offer strategy in this direction will be fruitful.

The results also confirmed the effectiveness of the **delayed acceptance strategy** on the settlement performance of (**H6** and **H7**). The seller utility in the DLY condition (mean=52.8; s.d.=7.2) was significantly higher than that in the IMM condition (mean=48.0; s.d.=5.7). The distance to the Nash solution in the DLY condition (mean=15.3; s.d.=5.8) was significantly smaller than that in the IMM condition (mean=19.2; s.d.=5.0). Contrary to **H8,** while the delayed acceptance strategy benefited the seller, it did not significantly affect buyers' satisfaction with the negotiation outcome (mean=4.52; s.d.=0.9 in DLY condition vs. mean=4.49; s.d.=1.2 in IMM condition). In the experiment, buyers were highly motivated to pursue self-utility; therefore the delayed acceptance had a more salient impact in protecting the seller's utility instead of further enhancing the buyer's utility. Thus a significant increase of buyers' perception was not demonstrated. Despite this, the delayed acceptance strategy still appeals to the win-win principle in that it preserved a negotiator's payoffs without projecting a negative image on the counterpart.

The regression results suggest that perceived cooperativeness was the only variable that significantly associated with buyers' **desire for future negotiation** (**H9**). Our data confirmed the impact of the negotiators' perception of cooperativeness on their willingness to return to their partners. The results further highlight the significance of a negotiation agent's capability to communicate friendliness and flexibility to the counterpart, which are critical to business relationship on top of its firmness in economic benefits.

Implications

The findings of this study have implications for negotiation theories, technological advancement, and the practice in electronic marketplaces. First, the findings of our research contribute to the understanding of strategies for multi-issue negotiation. The manipulation of negotiation strategies as formalized decision rules in a software agent allowed us to investigate their effects in a highly controlled manner. Conceptually speaking, a good strategy should be effective even with most uncooperative negotiators (Thompson 2009). Our empirical results confirmed that economically and socially desirable outcomes can be better achieved by careful planning and initiatives taken by one party. The task used in the experiment created a situation in which subjects were motivated to maximize their self-utility as long as an agreement could be reached. In such situations, agents with simultaneous-equivalent offers still achieved settlements that were more Pareto-efficient while making the buyer happier compared to agents with sequential-single offers. The delayed acceptance strategy confirms that agent can explore better outcomes. Our empirical results and post-hoc analysis also suggest that there can be intertwining processes undermining the impact of simultaneous-equivalent offer on settlement ratio, thus having implications for theoretical refinement.

Second, on the technological side, the motivation of our strategy model is to foster a win-win negotiation rather than a win-lose one. To the field of automated negotiation, our work presents a technically novel design artifact – an integrative, win-win-seeking intelligent agent – compared to traditional software agents that are designed in a distributive mode and bounded in their interaction to other software agents. Together, the simultaneous-equivalent offer and delayed acceptance strategies are shown to be able to provide a new way to explore more Pareto-efficient space in bilateral negotiations. As opposed to agent-to-agent simulation, our experimental study provides an empirical validation of the usefulness of software agents when negotiating with human counterparts.

Furthermore, the findings and the negotiation agent artifact can be potentially applied in today's B2B electronic marketplaces, where intelligent agents are increasingly used in semi-structured online business transactions. Our win-win negotiation strategy is based on more realistic assumptions of a negotiation setting, and hence can be used in open markets where there are many buyers and many sellers, and where knowledge of or prior interaction history with the counterpart is not available to the agent.

Conclusion and Future Research

This study proposes a novel strategy model for an automated agent to achieve a win-win negotiation outcome. We contend that a good negotiation strategy should account for both positive economic and social-psychological outcomes. Our experimental study suggests that, overall, without any prior knowledge of the counterpart based on extensive earlier interaction, the proposed strategies (simultaneous-equivalent offer and delayed acceptance) are effective in achieving win-win outcomes.

The findings of our present study open several avenues for future research. First of all, the current implementation of simultaneous-equivalent offers is used throughout the agent's planned number of rounds of offer exchange in a negotiation episode. In can be foreseen that if the negotiation task is more complex, or negotiation rounds are extended, the agent can learn enough information to estimate the opponent's preference structure. With such estimation, the agent may eliminate offers that are less attractive to the opponent in later rounds of a negotiation episode to reduce the cognitive load of its human counterpart. The effectiveness of such combined approach with both simultaneous-equivalent offers and guessing heuristics can be empirically tested in future research.

Second, the present study focused on the examination of the key strategic negotiation parameters on "what" offers can be proposed. The study did not explore the "how" aspect in offer making, i.e., how to make argumentation to enhance the persuasiveness of an offer. According to latest social-psychological analysis (Thompson 2009, p. 89; Medvec et al. 2005a), the simultaneous-equivalent offer strategy can help a negotiator to be more persistent and persuasive regarding a value of an offer. It would therefore be interesting to integrate argumentation features into the current strategy model. Because additional messages justifying an offer make the offer more attractive, it may alleviate the negative effect of simultaneous-equivalent offer strategy in "escalating" buyers' aspiration. Consequently, settlement ratio might be enhanced. Future research can be extended to incorporate the role of framing as an argumentation technique and its interaction with the strategy used in this study.

Furthermore, it is of both theoretical and practical interest to test the agent-based automated negotiation artifact in an interesting application domain, such as the software-as-a-service online marketplace. The agent approach to negotiation differs from traditional negotiation support systems based on the autonomy and flexibility of agent-based architecture to be offered as a service to human buyers in consumer settings, where fixed pricing is the norm at present. Our current system provides an initial step to this application.

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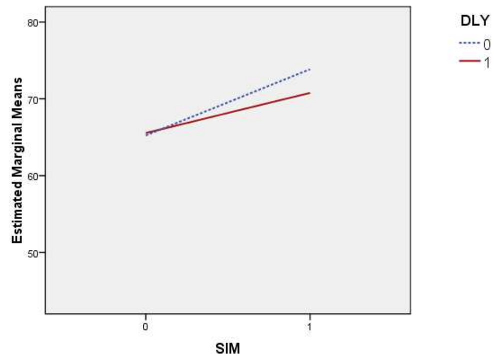
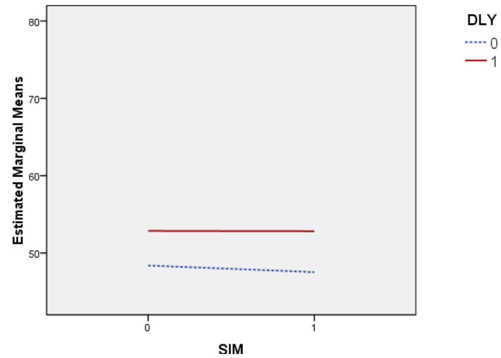
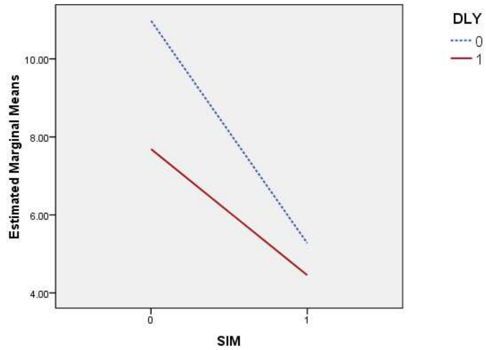
Appendix. Descriptive Statistics and Profile Plots of Dependent Variables



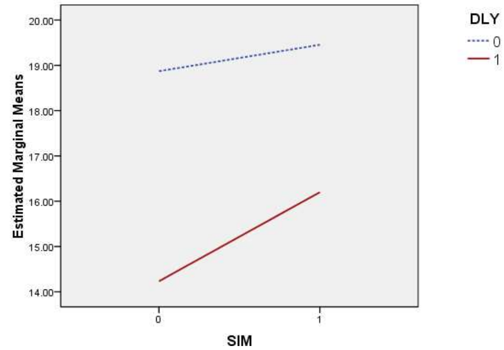
A-1. Mean of buyer utility



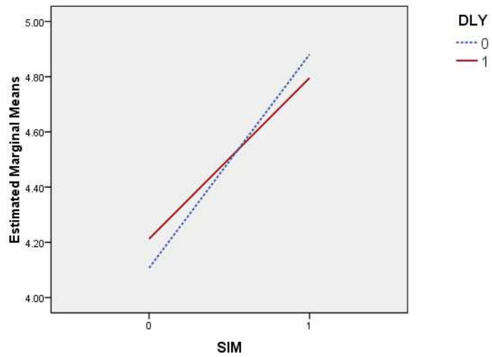
A-2. Mean of seller utility



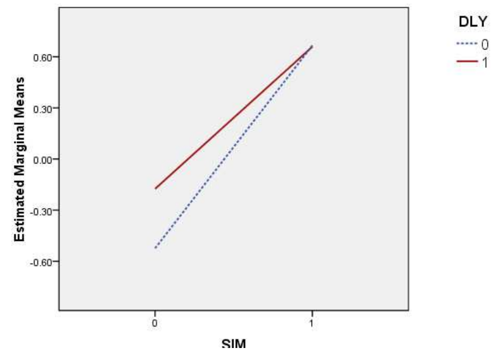
A-3. Mean of distance to Pareto-efficient frontier



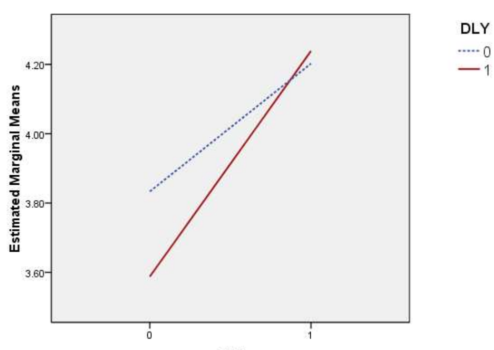
A-4. Mean of distance to Nash solution



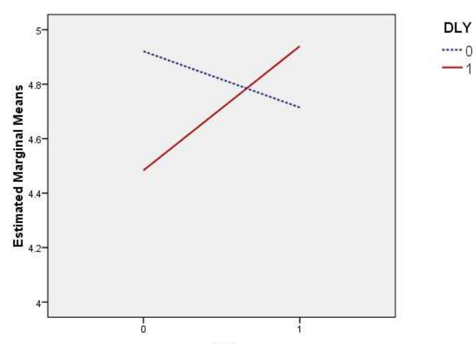
A-5. Mean of outcome satisfaction
(Perceived settlement efficiency dimension)



A-6. Mean of outcome satisfaction
(Perceived settlement fairness dimension)



A-7. Mean of perceived cooperativeness



A-8. Mean of desire for future negotiation